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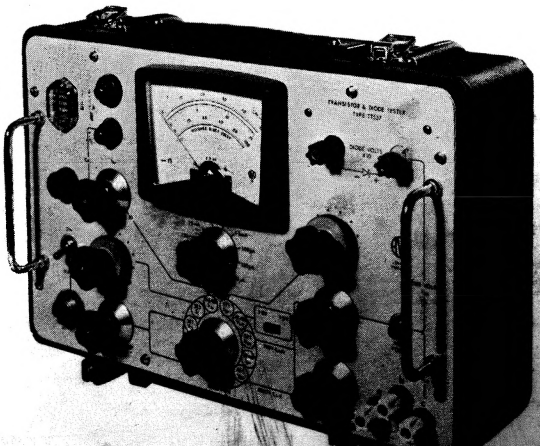
OPERATING INSTRUCTIONS

TRANSISTOR AND DIODE TESTER TYPE TT 537



OPERATING INSTRUCTIONS

CONTENTS

ILLUSTRATIONS

CHAPTER 1

PERFORMANCE

INTRODUCTION

The Avo Transistor and Diode Tester provides, in one instrument, facilities for both transistor and diode testing. The tester is a compact, simple to operate, direct reading instrument, providing an accurate and convenient method for the measurement of transistor and diode characteristics.

Provision is made for the rapid and accurate measurement of transistor h_{fe} up to 1500 at a frequency of approximately 1kc/s and the measurement of leakage current between 1μA and 400mA for both p.n.p. and n.p.n. low and medium power germanium or silicon transistors.

Both the forward and reverse characteristics of diodes can be measured, the reverse characteristics at voltages up to 1000V under current limiting conditions.

SPECIFICATION

Transistors:

Collector Voltage:	0 to 12V stabilised and continuously variable. (Monitored by panel meter.)
Collector current:	0 to 1A max. Monitored by CURRENT meter, in 10 ranges from 50μA to 1.5A f.s.d. (first indication 1μA).
Base Current:	Less than 0.1μA min., approx. 50mA max.
h_{fe}:	0 to 1500 in 4 ranges. Accuracy $\pm$ 1.5% of reading, $\pm$ 1.5% of f.s.d. Measurement of h_{fe} at collector currents lower than about 250μA will introduce progressively increasing errors into the result.
Leakage Current: (I_{CEO})	0 to 400mA max. Supply current limited to approximately 400mA with SET V_{CE} control fully clockwise. Monitored by CURRENT meter on 10 ranges from 50μA to 1.5A f.s.d. (first indication 1μA).
Overload Protection:	The collector power supply is protected against damage by being current limited to approximately 4A on short circuit. A 1A fuse in the collector power supply protects the lower value meter shunts against overheating under heavy overload conditions. A mains fuse protects against direct breakdown in the mains circuit. The meter movement is protected by a heavy duty silicon rectifier in shunt with the meter.

Diodes:

Forward Volt Drop: 5V and 1.5V f.s.d. measured across diodes with a forward diode current of 0 to 500mA.

Breakdown Voltage: 0 to 100V at 3mA. Current limited on short circuit to approximately 13mA.
0 to 1000 Volts at 200μA. Current limited on short circuit to approximately 1.3mA.

NOTE IMPORTANT. When the 'SET V_{DR}' control is turned fully clockwise and negligible current is being drawn it is possible for approximately 140V to appear at the 100V terminals on the 0 to 100 range and approximately 1200V at the 1000V terminals on the 0 to 1000 range. Since the meter full scale deflection is 100V or 1000V respectively, the meter full scale deflection will be exceeded.

CONSTRUCTION

The instrument is housed in a strong metal case designed in suitcase form for portability and ease of storage. The mechanical structure is such as to provide inherent rigidity of the assembly. The case contains the panel which carries all the controls and within the lid space is provided for housing the mains lead. a flying lead adaptor and a plug-in adaptor for use with short-lead transistors. supplied as an optional extra. When the lid is closed the case is showerproof and the panel is completely protected against accidental damage.

Precautions have been taken to ensure that any loose fragments of dust or metal inside the case do not interfere with the operation of the instrument.

Using a length of transfer tape a thin film of adhesive is deposited inside the case, in such a position, that any loose fragments of dust or metal will be attracted to the adhesive which will retain them indefinitely.

All components likely to require replacement or adjustment in service are conveniently located thus ensuring a maximum of accessibility. The majority of components are located on a hinged printed circuit board. this can be raised to permit access to panel mounted components. The bolts securing the printed circuit board form feet which protect the board from damage if the panel is removed from the case. If the panel is placed on a bench with the controls facing upward the bolts prevent the printed circuit board from actually touching the bench.

Dimensions: 15 in. x 9.5 in. x 5 in. (38 x 24 x 13 cm. approx.)

Weight: 21 lb. (9.5 kg.) approx.

MAINS SUPPLY

Voltage:	110, 120, 200, 220 and 240 $\pm$ 6%. The voltage is set by selecting the appropriate transformer tapping.
Frequency:	50—500c/s.
Power:	Approximately 50W.

WORKING TEMPERATURE

The instrument is designed to operate in ambient temperatures between 0°C and +55°C.

CHAPTER 2

TECHNICAL INFORMATION

The design of the instrument enables accurate measurements to be made with the minimum of adjustments and setting-up. The layout of the panel controls is such that operation of the instrument, which centres around a FUNCTION switch and a TRANSISTOR/DIODE SELECTOR switch, is largely self-explanatory. These features together with the protective devices incorporated in the instrument provide an ideal tester for use not only by engineers and technicians but also by unskilled personnel.

The instrument itself is protected against inadvertent misuse and whilst testing faulty transistors and diodes a 1A fuse in the collector supply protects the instrument from damage if currents greater than 1A should be drawn. When testing diodes in the reverse direction the short circuit current is limited to approximately 13mA on the 100V test and 1.3mA on the 1000V test. The controls are arranged to give the highest possible degree of additional protection during these diode reverse voltage tests. With the FUNCTION switch set at V_{DR} (the position for setting the diode reverse voltage) it is also necessary for the TRANSISTOR/DIODE SELECTOR switch to be in the DIODE position and finally for the push button PRESS V_{DR} to be depressed before the 100V or 1000V can be obtained at the output terminals.

Transistors too, are protected to some degree by the setting of the TRANSISTOR/DIODE SELECTOR switch. No meter reading is obtained on the SET V_{CE} position of the FUNCTION switch (the position at which the transistor collector voltage can be set) unless the TRANSISTOR/DIODE SELECTOR switch is set to p.n.p. or n.p.n.

When testing transistors the nominal collector voltage may be set down to zero. It should be noted, however, that the measuring facilities in the collector circuit will introduce a voltage drop. This could be as high as 300mV and will result in the actual collector voltage being lower than that indicated by the meter, by this amount. Due allowance should be made for this when making measurements at low collector voltage.

The indicating meter has a 50μA movement and a scale length of approximately 3.5 inches. Three simple scales calibrated 0 to 15, 0 to 50 and 0 to 100 are provided for all measurements and a CAL mark for use during h_{fe} measurements is also indicated. This calibration mark enables the measuring system to be accurately set up and ensures that any slight variation in amplifier gain or oscillator output level is adequately compensated for. All measurements are indicated directly on the panel meter and full monitoring facilities are provided. The meter is protected against overload by a shunt silicon diode.

The panel markings are colour-coded, and basically all markings around controls relating to transistor testing are black and all those used during diode testing are green. Controls common to both measurements are coded in black.

CHAPTER 3

CIRCUIT DESCRIPTION

POWER SUPPLIES

Two transformers T1 and T2 provide all power supplies for the instrument. With mains supply switch S1 set to the ON position, mains supply is applied to the primary of transformer T1 through fuse FS1. The transformer primary may be set for 110, 120, 210, 220 and 240 volt operation by means of the tappings provided.

Transformer T1 has four 17V secondary windings a, b, c and d which provide all lt supplies for the oscillator, amplifier and component under test. The heavy current winding d feeds a bridge circuit formed by MR1 to MR4 inclusive, the output of which is smoothed by capacitor C36. This unstabilised output of 22V at 1A is fed, via the power supply current limiting resistor R1, and the fuse FS2, to the compound pair, transistors VT1 and VT2, the series regulators for the stabilised power supply of 0 to 12V at 0 to 1A for collector supply and diode forward current.

Winding c energises the lamp ILP1 which gives visual indication that mains is applied to transformer T1. One side of this winding is connected to the zero voltage line of the 0 to 12V supply, the other is applied to diodes MR5 and MR6. From MR5 the output is fed via the smoothing circuit C1, R103 and C2 to provide 24V negative to the amplifier controlling the base of VT2. From MR6 an output is fed, via the reservoir capacitor C3 and the filter circuit R5, C5 and R6, to the zener diode stabiliser MR8 to provide a reference voltage supply for the stabiliser circuit VT1, VT2 and VT3. Transistor VT3 is an amplifier transistor whose emitter is held positive to the zero voltage line of the 12V supply by the zener diode MR9. R3 is the collector load of VT3. R4 provides a standing current to ensure the optimum operating conditions for MR9. Any changes in the output voltage tending to occur at the emitter of VT1 will be fed via the resistive potential divider chain to the base of the amplifier transistor VT3. Such changes are amplified by VT3 and applied in opposite phase to the base of VT2 thus counteracting any rise or fall in output voltage and stabilising the output accordingly. The amplifier transistor VT3 functions satisfactorily even with the output voltage reduced to zero and provides a good regulation over the complete range of collector voltage.

The output voltage is determined by the dc potential divider formed by RV1, R97, RV2, R8 and RV3, the pre-sets RV2 and RV3 being adjusted during manufacture to set the range of control of RV1. During operation the output may be set as desired within the range 0 to 12 volts by this potentiometer. Capacitor C6, serves to maintain the amplifier gain at ac frequencies and capacitor C7, connected across the 0 to 12V stabilised output, maintains the low impedance of the supply at high ac frequencies.

During diode forward testing, current limiting is provided by R47. Diode forward current is limited to 500mA with 5V drop across the diode, but on short circuit or with diodes of low forward volt drop the current is limited to approximately 800/900mA. Currents in excess of 500mA should not be employed continuously. (See 'Control of Diode Forward Current' following this description of Power Supplies.)

A third 17V secondary winding b supplies power for the dc base bias control circuit for the transistor under test. This circuit is designed to ensure that the base bias is practically free from both noise and ripple. The output from this winding is fed via the half wave rectifier MR10 to the two transistors VT4 and VT5 connected in series. These two transistors in conjunction with zener diode MR11 and a multiple filtering circuit provide a stable output at reasonably low impedance with noise and ripple reduced to an absolute minimum. The output from this circuit (nominally 10V at currents up to 60mA) is fed to the base current control circuit comprising transistors VT6 or VT7, dependent upon the polarity of the transistor under test. If an n.p.n. transistor is under test, the p.n.p. transistor VT6 will be in circuit and if p.n.p. transistor is being tested the n.p.n. transistor VT7 will be in circuit. The output from the appropriate transistor is a constant current supply of very high source impedance. The base current to the transistor under test is set by adjustment of the coarse control S8 and the fine control RV4, Ranges overlap with the fine control to provide complete coverage.

Winding a is half wave rectified by diode MR16 and fed via reservoir capacitor C4 and the current limiting resistor R2 to the zener diode stabiliser MR7. The output from MR7 provides 12V at approximately 13mA to feed the amplifier and oscillator.

Transformer T2 has a tapped secondary winding providing two separate ht power supplies. A half wave rectifier MR12 is fed from the nominal 100V tapping via the reservoir capacitor C11 to the smoothing circuit R22 and C12 to provide a reverse diode test voltage of 0 to 100V. A nominal 540 volt winding feeds the voltage doublers MR13 and MR14 to provide a reverse diode test voltage of 0 to 1000V. These two supplies are designed to operate without damage under short circuit conditions. The output voltage of both the 100V and the 1000V supply is set by the potentiometer RV5 in the primary of transformer T2. Mains voltage will not be applied to the primary of transformer T2 unless the TRANSISTOR/ DIODE SELECTOR switch S2 is in the DIODE position and the push button safety switch PRESS FOR V_{DR} is operated.

Control of Diode Forward Current

In addition to supplying collector supplies to the transistor under test the 0 to 12V, 0 to 1A stabilised output is also used to supply diode forward current to a diode under test. For this purpose, the resistor R47 is used as a current limiting resistor.

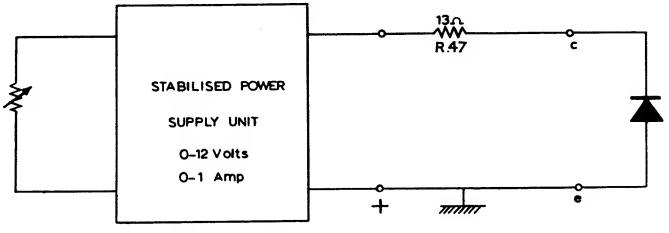


Fig. 1. DIODE FORWARD TEST.

In order to obtain fine control of diode forward current for the full range of 0 to 500mA, a dual control, comprising switch S9 and resistors R55 to R63 together with potentiometer RV7, is used to control the diode forward current. Switch S9 and associated resistors R55 to R63 inclusive provide coarse control and the potentiometer RV7 provides fine control, the ranges overlap with the fine control to provide complete coverage. The nominal maximum rating of diode forward current is 500mA but it should be noted that this current is obtainable with a 5V drop across the diode under test. Currents in excess of 500mA should not be employed continuously.

METER CURRENT RANGES

Resistors R35 to R43 inclusive are low temperature co-efficient shunts for the various ranges of current measurement. The appropriate shunt is selected by the CURRENT range switch S5. In order to ensure that the collector voltage is maintained constant, the volt drop across the meter must be reduced to a minimum. This means that the normal practice of 'swamping' the meter coil resistance (copper resistance) with a much larger resistor cannot be adopted. Compensation is therefore necessary for the change of meter coil resistance as temperature varies from normal ambient. This compensation is achieved by means of a shunted thermistor connected in series with the meter movement. the total resistance being adjusted to a value of 2.4k ohms $\pm$ 1% by a supplementary wire wound resistor. These components are not shown on the circuit diagram as they are located within the meter case and form part of the meter movement. This compensation has made it possible to use low temperature co-efficient shunts with minimum errors in measurement at the maximum operating ambient temperature.

h_{fe} CALIBRATION

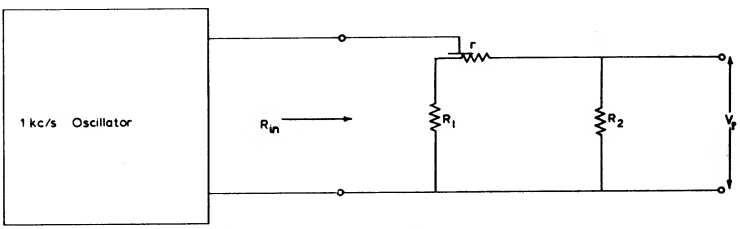


Fig. 2. h_{fe} CALIBRATION SIMPLIFIED CIRCUIT.

It is desirable that the output of the oscillator is maintained constant with variation in temperature. This can only be achieved if the resistive load of the oscillator is constant.

At the same time, it is essential to be able to vary the effective output in order to calibrate the oscillator/amplifier combination. The manner in which this is achieved may be seen by reference to Fig. 2. R_{in} is approximately constant if $R_1 = R_2$ and r is much smaller than $(R_1 + R_2)$, but V_o is variable to allow for calibration adjustment.

Referring now to Fig. 3, which shows how the arrangement in Fig. 2 is actually incorporated into the circuit of the instrument, r becomes RV6, R_1 becomes R29 and R_2 is the parallel combination of R30, R31, R32, R33, R34 and R54.

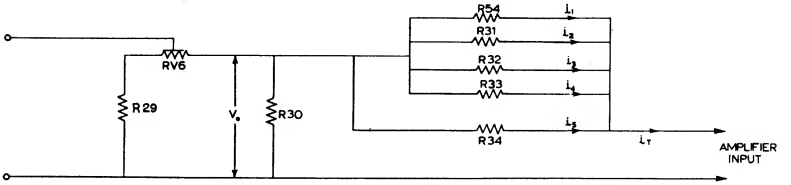


Fig. 3. h_{fe} CALIBRATION CIRCUIT.

When the h_{fe} range switch is set to CAL the currents i_1 to i_5 inclusive are combined and the total current is fed to the amplifier input which has negligible impedance. Potentiometer RV6 is then set to give full scale deflection on the meter. This sets i_1, i_2, i_3 and i_4 each to a predetermined value. One of these, as appropriate to the h_{fe} range in use, is then injected into the base of the transistor under test to provide the calibrated 1kc/s signal. The ratios of these currents to each other and to the total current i_T are determined by the ratios of the resistors R54, R31, R32, R33 and R34.

It will be appreciated, therefore, that the accuracy of h_{fe} measurement at full scale deflection is set solely by the accuracy of resistor ratios.

OSCILLATOR CIRCUIT

This is basically a Wien Bridge oscillator, the frequency of oscillation being determined mainly by the series elements R64 and C18, together with C19 in shunt with the effective parallel combination of R65, R66 and the input impedance of VT8. The predominant resistive factors in the parallel element are R65 and R66.

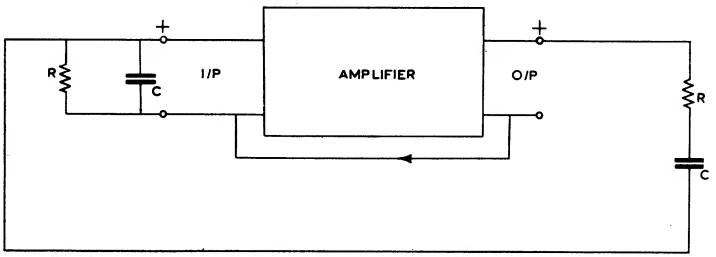


Fig. 4. OSCILLATOR CIRCUIT BLOCK DIAGRAM.

Transistors VT8 and VT9 form a low gain amplifier with negligible phase shift at the oscillator frequency of 1kc/s. Transistor VT10 is an emitter follower to handle the current requirements in the output circuit. Feedback is taken from the junction of resistor R76 and thermistor TH2, the values of these components being chosen such that constancy of output is maintained for any changes other than ambient temperature changes. The operating current through thermistor TH2 is set during manufacture, by adjustment of potentiometer RV8 connected in the emitter circuit of VT8, to give a volt drop across R76 of 400 millivolts r.m.s.

The effect on the amplitude of the oscillator output due to ambient temperature changes is compensated for by the parallel connected components, thermistor TH1 and resistor R77. To ensure the correct degree of compensation the calibration network is designed such that the load on the oscillator is maintained approximately constant at 3.3k ohms.

AMPLIFIER CIRCUIT

Transistor VT11, together with current transformer T3, provide a low impedance input to the amplifier. Thus the impedance presented to the collector of the transistor under test is reduced to a minimum, the ac impedance being approximately one eighth ohm and the dc resistance approximately 60m ohms.

The signal current from the collector of the transistor under test is reduced by the current transformer T3 in the ratio 20:1 and fed into the emitter of VT11 via the coupling capacitor C24. VT11 is a high gain transistor which ensures that almost the entire signal current flows through to the collector load and this is virtually unaffected by temperature.

A voltage is developed at the base of VT12 which is determined by the magnitude of the signal current in the collector of VT11 and the effective ac impedance of VT11 collector circuit. (The effective impedance of the parallel combination R78, R84, R85 is approximately equal to 5k ohms.)

A signal voltage at low impedance is fed from the emitter follower VT12 to the input of the high stability negative feedback amplifier comprising VT13, VT14 and their associated components. The output circuit is arranged such that the ac signal current flowing in VT14 collector is rectified by MR17 and MR18. Its mean value is then displayed on an external ammeter which may be connected to terminations 41 and 42.

The feedback resistor R95 in shunt with R91 defines the sensitivity of the amplifier and as this is fairly high, suitable precautions have been taken to eliminate pick-up of spurious signals. Magnetic coupling between the input transformer and any stray magnetic fields is overcome by screening the input transformers with a mu-metal box. The effect of ripple in the power supply feeding the amplifier is reduced to a minimum by the de-coupling arrangements, R82 and C26, R83 and C27 and R87 and C28.

CONTROLS

All controls are panel mounted and their functions are clearly indicated adjacent to the relevant control. A main FUNCTION switch, in conjunction with a TRANSISTOR/DIODE SELECTOR switch, selects the available facilities, the remaining controls set the appropriate test conditions for either transistors or diodes. Details of the controls are as follows:—

Function switch

The FUNCTION switch is a twelve position switch which is set as required for the type of measurement to be made. The markings which indicate the facilities are as follows:—(commencing at the OFF position and continuing clockwise around the switch).

OFF: No measurement can be made at this position. Although the instrument may be switched on, no voltage is available at the terminals for test purposes. The meter movement is shorted out in this position. Thus the FUNCTION switch should be set to OFF during transit.

SET V_{CE}: At this position control of Collector Voltage is carried out by the SET V_{CE} control (12V max.). Voltage is not fed to the output terminals but is monitored on the panel meter on the scale marked 0-15 provided the TRANSISTOR/DIODE SELECTOR switch is set to npn or pnp.

NOTE: The base dc path is open circuit.

READ I_{CEO}: In this position voltage is available at the output terminals and I_{CEO} is indicated directly on the meter, the appropriate meter range being selected by the CURRENT control. The supply to the collector is current limited to 400mA on short circuit at maximum V_{CE}.

SET V_{CE}: At this position collector voltage may be set for h_{fe} measurement. The circuit conditions are similar to those at the previous SET V_{CE} position.

SET I_C: Collector voltage is applied to the collector terminal via the current metering circuit and the input of the amplifier. The panel meter will monitor collector current on a range selected by the CURRENT range switch. The dc base bias will be fed to the transistor under test from the base control circuit. Base current is adjusted by the SET I_C control. No ac signals are fed to the base.

READ h_{fe}:

In this position conditions are similar to the SET I_C position except that a calibrated ac signal at a frequency of 1kc/s is fed into the base of the transistor under test and the meter is switched to the output of the amplifier to read h_{fe}. The ranges of measurement available are:— 50, 150, 500, 1500 f.s.d. At this position too, with the associated h_{fe} control set to the CAL position, full scale accuracy of the h_{fe} ranges may be set. (See h_{fe} Control.)

SET I_{DF}:

This position is used for diode forward measurements. In conjunction with the SET I_{DF} control diode forward current may be set. The meter measures the diode current, the full number of current ranges being available as set by the CURRENT control. In this position the anode and cathode of the diode under test are connected to the emitter and collector terminals respectively.

READ V_{DF}:

At this position the meter indicates diode forward voltage with a full scale reading of 5V or 1.5V dependent upon the setting of the slide switch. The circuit conditions are similar to those at the SET I_{DF} position, but the circuit is arranged such that the panel meter together with an appropriate multiplier resistor is now connected as a voltmeter.

SET V_{DR}:
(100V f.s.d.)

At this position with the TRANSISTOR/DIODE SELECTOR switch set to DIODE and the push button depressed the REVERSE DIODE VOLTS control can be set to apply any voltage between 0 and 100V across the diode. The voltage will be indicated on the panel meter on the scale marked for this function.

READ I_{DR}:
(100V f.s.d.)

The metering circuit is arranged to read diode leakage current as set by the CURRENT switch. Current is limited on short circuit to 13mA.

SET V_{DR}:
(1000V f.s.d.)

This is identical to the SET V_{DR} (100V f.s.d.) position described above except that the voltage can be set to apply between 0 and 1000V to the diode. In this position, too, the diode under test must be connected to the DIODE VOLTS X10 terminals.

READ I_{DR}:
(1000V f.s.d.)

This is identical to the READ I_{DR} (100V f.s.d.) position described above.

TRANSISTOR/DIODE SELECTOR SWITCH:

This switch selects the appropriate polarity for the transistor under test, or the position for diode measurements. The switch has four positions, npn, OFF, pnp and DIODE, the npn and pnp positions being used during transistor testing and the DIODE position for diode measurements. The following protective features are offered by this switch:— At the OFF position no voltage is available at any of the five output terminals as at the OFF position of the FUNCTION switch. The SET V_{CE} metering circuit is broken unless this switch is set to npn or pnp. Similarly the mains input to the ht transformer is broken in all position except the DIODE position.

CURRENT SWITCH:

This is the range switch which selects the appropriate meter movement shunt for all current measurements. Using this switch the current may be monitored on any one of nine ranges between 50μA and 1.5A f.s.d.

INDICATING METER:

A moving coil meter with a sensitivity of 50μA and a total meter resistance of 2.4k ohms $\pm$ 1%. The meter is compensated for resistance changes due to temperature and it is protected by a shunt silicon diode. There are three scales 0 to 15, 0 to 50, and 0 to 100 covering all measurements. A CAL position is marked for use when setting up the instrument for h_{fe} measurements (See h_{fe} Control).

SET V_{CE} CONTROL:

A simple potentiometer control which enables collector/emitter voltage to be set to any value between 0 and 12 volts. The voltage is monitored by the panel meter on the scale marked 0 to 15, i.e. 15 volts full scale deflection, provided that the TRANSISTOR/DIODE SELECTOR switch is in either the npn or pnp position.

SET I_C CONTROL:

This control provides adjustment for the dc base bias current fed to the transistor under test and is operative at positions SET I_C and READ h_{fe} of the FUNCTION switch, although it is normally used only in the SET I_C position at which position the collector current is monitored by the meter. It is a dual control, coarse settings are provided by a switch operated by the control ring and fine settings by the potentiometer knob. Ranges overlap with the fine control to provide complete coverage.

h_{fe} CONTROL:

Full scale values of h_{fe} measurement are set by selecting the appropriate range on this switch, i.e. 50, 150, 500 or 1500 f.s.d. An additional position, CAL, is provided, in which position provision is made to calibrate the h_{fe} measuring circuits by adjusting the potentiometer h_{fe} until the meter pointer lies on the calibration mark at f.s.d. This control is used only when the FUNCTION switch is set to h_{fe}.

SET I_{DF} CONTROL:

A dual control similar to SET I_C. With the FUNCTION switch set to the SET I_{DF} position this control can be adjusted to obtain the required test current as monitored by the meter for diode forward voltage measurements. Coarse adjustment is provided by a ten position switch operated by the control ring and fine control by the potentiometer knob. Ranges overlap with the fine control to provide complete coverage. The control provides adjustment of the stabilised 0 to 12V normally used for supplying the collector of a transistor under test. Diode current is regulated by a current limiting resistor. The diode maximum current is intended to be 500mA and circuits may be operated continuously under these conditions. However, in order to provide 500mA at a diode voltage drop of up to five volts it will be found that currents higher than 500mA may be obtained when the diode voltage drop is lower. A current higher than 500mA should only be used for short term operation.

V_{DF} RANGE SWITCH: (5.0V—1.5V)

This is a simple two position slide switch enabling full scale ranges of 1.5V and 5.0V to be obtained on the meter when measuring diode forward voltage at the current set by SET I_{DF} control.

REVERSE DIODE: VOLTS

This potentiometer controls the mains input to the ht transformer and provides adjustment for both the 100V and 1000V supplies. This control is only operative when the TRANSISTOR/DIODE SELECTOR switch is set to the DIODE position and the push button PRESS FOR V_{DR} is depressed.

PRESS FOR V_{DR}

A spring loaded switch which is intended as a safety device. This switch closes the mains circuit to the primary of the ht transformer only so long as it is depressed, and only if the TRANSISTOR/DIODE SELECTOR switch is in the DIODE position.

TERMINALS e.b.c. (emitter, base, collector)	These are the terminals to which a transistor is connected either directly or via the transistor extension lead or adaptor. The e and c terminals are also used for testing diode forward and reverse characteristics up to 100V. The diodes are connected as indicated on the front panel, anode to e and cathode to c.
DIODE VOLTS X10	These two terminals are used only for diode reverse testing above 100V. The diode is connected as shown by the symbol on the front panel.
MAINS SUPPLY SWITCH:	A double pole switch. At the off position the mains voltage is broken on both lines immediately after the input plug. The mains voltage is therefore removed from the mains fuse in the off position. When set to the ON position mains is applied to transformer T1.
L.T. FUSE 1 Amp.	This fuse, located on the front panel, is situated electrically in the 1 Amp lt. supply used for feeding the collector of the transistor under test. It is placed between the unstabilised power supply and the 0-12 Volt stabiliser so that its resistance will not add to the source impedance of the stabilised supply. Its primary purpose is to protect the low value meter shunts, under overload condition.
MAINS FUSE 1A:	A simple fuse in the live side of the mains input. Slow blow characteristics are required due to the surges which may arise with C core transformers. This fuse, which seldom, if ever, requires replacement is mounted internally. Access is obtained by removing the instrument from its case. The fuse is located behind the panel meter.
VOLTAGE SELECTOR:	This enables the input to the lt. transformer to be set to the tapping suitable for the mains supply available. The ht transformer is fed from a constant tapping on the l.t. transformer and does not require separate adjustment.
LAMP:	A 24V, 2.8W bayonet fitting bulb. This is energised by a 17V winding on the lt transformer which gives adequate brilliance. By under-running the lamp in this manner its life is considerably extended.
MAINS INPUT PLUG:	This is a three way Mk. 4 aluminium fixed plug with position 5 orientation. The connections are as follows:— a—live side of the mains. b—neutral side of the mains. c—earth connection.

CHAPTER 4

OPERATING INSTRUCTIONS

GENERAL

Before connecting the instrument to the mains supply set all controls to the positions indicated below:

(a) Mains supply switch set to the off position.
(b) Mains Voltage Selector set to a tapping appropriate to the supply voltage available.
(c) Rotate SET V_{CE} control to minimum (fully counter clockwise).
(d) Rotate SET I_C two gang control to minimum (fully counter clockwise).
(e) Set h_{fe} range switch to 1500.
(f) Set the FUNCTION switch to OFF.
(g) Set the CURRENT range switch to 1.5A.
(h) Set the Slide switch to 5.0V.
(j) Set the TRANSISTOR/DIODE SELECTOR switch to OFF.
(k) Set the REVERSE DIODE VOLTS control to minimum (fully counter clockwise).
(m) Rotate SET I_{DF} two gang control to minimum (fully counter clockwise).
(n) When the controls are set to the positions indicated the mains supply may be connected to the mains plug and the supply switch set to the ON position.
(p) Check that the indicator lamp is illuminated.

TRANSISTOR MEASUREMENTS

h_{fe} Calibration Check

(a) Set the FUNCTION switch to READ h_{fe}.
(b) Set the h_{fe} range switch to CAL.
(c) If necessary, adjust the h_{fe} potentiometer (located on the front panel) for meter full scale deflection (CAL).
(d) Set the FUNCTION switch to the OFF position.

Transistor Leakage I_{CEO}

(a) Connect the transistor under test either directly to the terminals e, b and c or via the extension lead or adaptor as required.
(b) Set the TRANSISTOR/DIODE SELECTOR switch to pnp or npn as required.
(c) Set the FUNCTION switch one step clockwise from the OFF position to SET V_{CE}.
(d) Adjust the SET V_{CE} control until the required collector voltage within the range 0 to 12 volts is indicated on the meter (scale marked 0 to 15 volts).
NOTE: No meter reading will be obtained at this position unless the TRANSISTOR/DIODE SELECTOR switch is set to pnp or npn.

(e) Set the FUNCTION switch to the next position READ I_{CEO}.

(f) Set the CURRENT range switch to the appropriate range. The value of I_{CEO} will now be indicated on the meter.

(g) Return the CURRENT range selector to the 1.5A range.

h_{fe} Measurement

(a) Continue rotation of the FUNCTION switch to the second SET V_{CE} position.

(b) Adjust the SET V_{CE} control to the required collector voltage as monitored by the meter.

(c) Set the FUNCTION switch to the SET I_C position.

(d) Set the CURRENT range switch to the appropriate range for the test current required.

(e) Adjust the two gang SET I_C control (rear control, coarse; front control, fine) for the required test current conditions. (Measurement of h_{fe} at collector currents lower than about 250μA will introduce progressively increasing errors into the result.

(f) Set the FUNCTION switch to READ h_{fe}.

(g) Set the h_{fe} range switch to an appropriate range for the transistor under test. The value of h_{fe} will now be indicated on the meter.

This completes the transistor testing. It is recommended that the following controls should be returned to the position indicated:

(a) Set the FUNCTION switch to the OFF position.

(b) Rotate the SET V_{CE} control fully counter clockwise.

(c) Rotate the SET I_C controls fully counter clockwise.

(d) Set the h_{fe} control to 1500.

(e) Set the CURRENT range switch to 1.5A.

(f) Set the TRANSISTOR/DIODE SELECTOR switch to OFF.

DIODE MEASUREMENTS

Diode Forward Characteristic

(a) Connect the diode under test across the e and c terminals as indicated on the front panel. (Anode to e, cathode to c.)

(b) Set the FUNCTION switch to SET I_{DF}.

(c) Set the CURRENT range switch as appropriate for the test current required.

(d) Set the TRANSISTOR/DIODE SELECTOR switch to DIODE.

(e) Adjust the SET I_{DF} controls (rear control, coarse; front control, fine) to obtain the required test current as monitored by the meter. (For continuous operation the maximum current permitted is 500mA. (See Chapter 3, Control of Diode Forward Current.))

(f) Set the FUNCTION switch to READ V_{DF}.

(g) Diode forward voltage will now be indicated on the panel meter. Select the appropriate voltage range using the SLIDE switch. (If the measured voltage exceeds that given in data, the diode is below specification.)

This completes Diode Forward Characteristic Test. The controls should now be returned to the following positions:—

The SLIDE switch to the 5.0V position, the I_{DF} controls fully counter clockwise and the CURRENT switch to 1.5A.

Diode Leakage

(1) **0 to 100V Reverse Voltage**

(a) Set the FUNCTION switch to SET V_{DR} 100V f.s.d.

(b) Depress the push button PRESS FOR V_{DR} and hold down, whilst adjusting the REVERSE DIODE VOLTS to the test voltage required as monitored by the panel meter. The push button must remain depressed for the duration of the test.

(c) Set the CURRENT range switch to the appropriate range for the measurement of I_{DR}.

(d) Set the FUNCTION switch to READ I_{DR}. The panel meter will now indicate I_{DR} while the push button is depressed. (If the measured current exceeds that given in data, the diode is below specification.)

(e) Release the push button to disconnect the ht supply.
NOTE: If negligible current is being drawn it is possible for approximately 140V to appear at the 100V terminals when the SET V_{DR} control is turned fully clockwise. Since the meter full scale deflection is 100V, the meter full scale deflection will be exceeded.

(2) 0 to 1000V Reverse Voltage

(a) Connect the diode under test to the red and black terminals DIODE VOLTS X10 observing polarity as indicated on the front panel.

(b) Set the FUNCTION switch to SET V_{DR} 1000V f.s.d.

(c) Set the REVERSE DIODE VOLTS control fully counter clockwise. Depress the push button PRESS FOR V_{DR} and hold down whilst adjusting the REVERSE DIODE VOLTS to the test voltage required as monitored by the panel meter. The push button must remain depressed for the duration of the test.

(d) Set the CURRENT range switch to the appropriate range for the measurement of I_{DR}.

(e) Set the FUNCTION switch to READ I_{DR}. The panel meter will now indicate I_{DR} while the push button is depressed. (If the measured current exceeds that given in data, the diode is below specification.)

(f) Release the push button to disconnect the ht supply.
NOTE: If negligible current is being drawn it is possible for approximately 1200V to appear at the 1000V terminals when the SET V_{DR} control is turned fully clockwise. Since the meter full scale deflection is 1000V, the meter full scale deflection will be exceeded.

This completes Diode Reverse Characteristic Measurement. It is recommended that the controls be returned to the position indicated:—

(a) Set REVERSE DIODE VOLTS potentiometer fully counter clockwise.

(b) Set the CURRENT range Switch to 1.5A.

(c) Set the TRANSISTOR/DIODE SELECTOR switch to OFF.

(d) Set the FUNCTION switch to OFF.

POSITION OF CONTROLS WHEN NOT IN USE

At the completion of testing or when the instrument is not in use, it is recommended that the controls be set as follows:—

(a) Supply switch set to OFF.

(b) Rotate SET V_{CE} control fully counter clockwise.

(c) Rotate SET I_C two gang control fully counter clockwise.

(d) h_{fe} range switch set to 1500.

(e) The FUNCTION switch set to OFF. (The meter movement is shorted out at this position providing protection for the meter, particularly during transit.)

(f) The CURRENT range switch set to 1.5A.

(g) The SLIDE switch set to 5.0V.

(h) The TRANSISTOR/DIODE SELECTOR switch set to OFF.

(j) The REVERSE DIODE VOLTS control fully counter clockwise.

(k) The SET I_{DF} two gang control fully counter clockwise.

CHAPTER 5

CALIBRATION AND TEST PROCEDURE

CALIBRATION PROCEDURE

An a.c. millivoltmeter will be required which is suitably calibrated to read 400 millivolts accurately at 1kc/s. The meter must have an input impedance greater than 10kΩ on the appropriate range.
Before making any adjustments check the mechanical zero of the instrument and adjust if necessary.

Oscillator

(a) Connect the millivoltmeter across the red and yellow test points located on the printed circuit board.

(b) Set the mains supply switch to the ON position

(c) To set the voltage across R76 to the correct operating value adjust potentiometer RV8 (500Ω) in the emitter of VT8 for a reading of 400 millivolts on the millivoltmeter.

(d) Remove the millivoltmeter and set the mains supply switch to the OFF position.

Adjustment of range of SET V_{CE} control

This adjustment must be carried out with the instrument in a horizontal position.

(a) Set the mains supply switch to the ON position.

(b) Set the main FUNCTION switch to SET V_{CE} and the TRANSISTOR/ DIODE SELECTOR switch at either p.n.p. or n.p.n.

(c) Adjust the SET V_{CE} control (12V max.) to the fully anti-clockwise position.

(d) Adjust the pre-set potentiometer RV2 (SET OV) for zero voltage on the panel meter.

(e) Adjust the SET V_{CE} control to the fully clockwise position.

(f) Adjust RV3 (SET 12V) for an output voltage of 12 volts as monitored by the panel meter.

(g) Return the SET V_{CE} control to the fully anti-clockwise position and re-check zero setting. If necessary adjust RV2 (SET OV) and repeat tests (f) and (g).

(h) Repeat tests (f) to (h) inclusive until RV1 and RV3 require no further adjustment.

TEST PROCEDURE

The following test details provide a rapid method of determining whether the instrument is functioning correctly. These tests, which cover all positions of the main FUNCTION switch can be performed without removing the instrument from its case and without the use of external instruments, with the exception of one test which requires a Model 8 Avometer.

Collector Voltage (1st SET V_{CE} position)

(a) Set the mains Voltage Selector to a tapping appropriate to the supply voltage available and ensure that all controls are in the position detailed in the first paragraph (GENERAL) of the Operating Instructions.

(b) Connect the instrument to the mains supply and set the mains supply switch to the ON position. Check that the indicator lamp is illuminated.

(c) Set the main FUNCTION switch to position 2 (SET V_{CE}) and rotate the SET V_{CE} control fully clockwise. The panel meter should *not* read.

(d) Return the SET V_{CE} control to the fully anti-clockwise position.

(e) Set the TRANSISTOR/DIODE SELECTOR switch to pnp and rotate the SET V_{CE} control clockwise. The meter should now indicate. With the SET V_{CE} control fully anti-clockwise the meter should read 0 volts, and with this control fully clockwise the meter should read 12 volts (15V f.s.d.).

(f) Repeat (e) with the TRANSISTOR/DIODE SELECTOR switch set to npn. The meter should read as indicated in (e).

(g) Repeat (e) with the TRANSISTOR/DIODE SELECTOR switch set to DIODE. The meter should *not* read.

Leakage Current Ranges (READ I_{CEO})

(a) Set the main FUNCTION switch to the READ I_{CEO} position and check that the CURRENT range switch is in the 1.5A position. Short circuit the c and e terminals.

(b) Rotate the SET V_{CE} control clockwise slowly. The meter indication should rise steadily to 400mA approximately.
CAUTION: This test should not be prolonged unnecessarily at full short circuit current of approximately 400mA.

Collector Voltage (2nd SET V_{CE} position)

(a) Set the main FUNCTION switch to the second SET V_{CE} position. Repeat tests (a) to (g) detailed for the previous SET V_{CE} position.

Base Current (SET I_C)

(a) Connect the Avometer Model 8, set to a suitable dc current range, between the b and e terminals.

(b) Using the SET I_C control, the base current may be checked on each range.
Check that ranges overlap with the fine control to provide complete coverage between approximately 0.1μA and 50mA and also observe the polarity of the output. With the TRANSISTOR/DIODE SELECTOR switch set to npn, the b terminal will be positive to e, but when set to pnp the b terminal is negative to e.

h_{fe} Calibration

(a) Set the main FUNCTION switch to h_{fe} and the h_{fe} range switch to CAL. The panel meter should indicate full scale deflection.

Diode Forward Current

(a) Set the main FUNCTION switch to SET I_{DF}. Set the CURRENT range switch to the 1.5A range and short the e and c terminals.

(b) Rotate the SET I_{DF} control clockwise and observe the panel meter. The meter should not read unless the TRANSISTOR/DIODE SELECTOR switch is in the DIODE position. A maximum current of approximately 800/900mA will be obtained, but it is important not to prolong the test above 500mA.

Diode Forward Volt Drop

(a) Set the main FUNCTION switch to READ V_{DF}. With the terminals e and c open circuit cautiously rotate the SET I_{DF} control clockwise. The voltage should be indicated on the panel meter. Check correlation of readings on the two voltage ranges (1.5V and 5V).
CAUTION: Under these open circuit conditions it is possible to apply up to 12 volts across the metering circuit, by operation of the SET I_{DF} control. The meter reads 1.5V or 5.0V f.s.d. according to the position of the slide switch. For this test therefore, the SET I_{DF}. control should be operated with great care.

Diode Reverse Voltage (100V f.s.d.)

(a) Set the main FUNCTION switch to the SET V_{DR} (100V f.s.d.) position. Depress the pushbutton PRESS FOR V_{DR} and operate the REVERSE DIODE VOLTS control whilst observing the panel meter. The meter should indicate only when the TRANSISTOR/DIODE SELECTOR switch is in the DIODE position.
NOTE: With no load at the output terminals the meter full scale deflection can be exceeded.

Diode Reverse Current (100V f.s.d.)

(a) Set the main FUNCTION switch to READ I_{DR} (100V f.s.d.) and the CURRENT range switch to the 15mA range. Short the c and e terminals.

(b) Depress the pushbutton PRESS FOR V_{DR} and rotate the REVERSE DIODE VOLTS control clockwise. The meter should indicate a maximum short circuit current of approximately 13mA.

Diode Reverse Voltage (1000V f.s.d.)

(a) Set the main FUNCTION switch to SET V_{DR} (1000V f.s.d.). Depress the pushbutton PRESS FOR V_{DR} and operate the REVERSE DIODE VOLTS control whilst observing the panel meter. The meter should indicate reverse diode voltage only when the TRANSISTOR/DIODE SELECTOR switch is in the DIODE position.
NOTE: The voltage as indicated by the panel meter appears across the high voltage teminals. With no load at the output terminals the meter full scale deflection can be exceeded and the voltage at the terminals can be as high as 1200V.

Diode Reverse Current (1000V f.s.d.)

(a) Set the main FUNCTION switch to READ I_{DR} (1000V f.s.d.). Short the high voltage terminals and set the CURRENT range switch to the 1.5mA range.

(b) Depress the pushbutton PRESS FOR V_{DR} and rotate the REVERSE DIODE VOLTS control clockwise. The meter should indicate a maximum short circuit current of approximately 1.3mA.

CHAPTER 6

TABLE OF COMPONENTS

CAPACITORS, fixed

Circuit Ref:	Value µF	Toll %	Rating Volts	N.S. No.	Avo Part Number
C1	2200	+100-20	25	Plessey	27463-119
C2	1000	+ 50-20	25	5910-99-946-2715	27463-104
C3	500	+100-20	25	5910-99-946-3613	27463-331
C4	500	+100-20	25	5910-99-946-3613	27463-331
C5	500	+100-20	25	5910-99-946-3613	27463-331
C6	2	+100-20	30	5910-99-951-6507	27463-209
C7	1000	+100-20	15	5910-99-951-3157	27463-361
C8	500	+100-20	25	5910-99-951-3613	27463-331
C9	500	+100-20	25	5910-99-946-3613	27463-331
C10	500	+100-20	25	5910-99-946-3613	27463-331
C11	4	+ 50-20	150	5910-99-945-3008	27462-683
C12	4	+ 50-20	150	5910-99-945-3008	27462-683
C13	0.25	20	1k	Hunts	27337-516
C14	0.25		1.5k	5910-99-011-1459	27312-408
C15	1000	+100-20	15	5910-99-951-3157	27463-361
C16	0.1	10	250	C281VV/A100K	27538-207
C17	1000	+100-20	15	5910-99-951-3157	27463-361
C18	0.0295	1	125	Special	27522-538
C19	0.0295	1	125	Special	27522-538
C20	100	+100-20	6	5910-99-972-7852	27463-276
C21	50	+100-20	25	5910-99-913-4561	27463-273
C22	100	+100-20	6	5910-99-972-7852	27463-276
C23	250	+100-20	12		27463-313
C24	100	+100-20	6	5910-99-972-7852	27463-276
C25	100	+100-20	6	5910-99-972-7852	27463-276
C26	50	+100-20	25	5910-99-913-4561	27463-273
C27	10	+100-20	25	5910-99-110-2548	27463-217
C28	2	+100-20	30	5910-99-951-6507	27463-209
C29	0.22	10	250	C281VV/A100K	27538-209
C30	50	+100-20	25	5910-99-913-4561	27463-273
C31	10	+100-20	25	5910-99-110-2548	27463-217
C32	10	+100-20	25	5910-99-110-2548	27463-217
C33	10	+100-20	25	5910-99-110-2548	27463-217
C34	10	+100-20	25	5910-99-110-2548	27463-217
C35	0.1	10	250	C281VV/A100K	27538-207
C36	10,000		25	106-16103	27471-643
C37	4700pF	20	160	5910-12-140-7104	27532-117

RECTIFIERS

Circuit Ref:	Type	Manufacturer	C.V. No.	Avo Part Number
MR1	6F5	I.R.	CV7384	28461-306
MR2	6FR5	I.R.	CV7379	28461-307
MR3	6F5	I.R.	CV7384	28461-306
MR4	6FR5	I.R.	CV7379	28461-307
MR5	6F5	I.R.	CV7384	28461-306
MR6	6FR5	I.R.	CV7379	28461-307
MR7	1Z12	I.R.	CV7419	28475-281
MR8	IZ8.2	I.R.	CV7415	28474-530
MR9	IZ5.6	I.R.	CV7411	28474-264
MR10	6FR5	I.R.	CV7379	28461-307
MR11	1Z10	I.R.	CV7417	28474-816
MR12	SD94S	I.R.		28464-719
MR13	46H18	S.E.I	CV7046	27744-118
MR14	46H18	S.E.I	CV7046	27744-118
MR15	6F5	I.R.	CV7384	28461-306
MR16	6FR5	I.R.	CV7379	28461-307
MR17	IN914	Texas	CV7367	28433-801
MR18	IN914	Texas	CV7367	28433-801

RESISTORS, fixed

Circuit Ref	Value Ohms	Tol ±%	Rating Watts	N.S. No.	Avo Part Number
R1	27	5	50	Welwyn 1G53	A26787-111
R2	300	2	0.5	MR30	26834-442
R3	3.9k	2	0.5	MR30	26834-469
R4	1.8k	2	0.5	MR30	26834-461
R5	180	2	0.5	MR30	26834-437
R6	180	2	0.5	MR30	26834-437
R7	4.7k	2	0.5	MR30	26834-471
R8	1k	2	0.5	MR30	26834-455
R9	270	2	0.5	MR30	26834-441
R10	270	2	0.5	MR30	26834-441
R11	270	2	0.5	MR30	26834-441
R12	200	2	0.5	MR30	26834-438
R13	100	2	0.5	MR30	26834-431
R14	470k	5	0.25	2114	26252-237
R15	150k	2	0.5	MR30	26834-507

RESISTORS, fixed (Contd.,)

Circuit Ref	Value Ohms	Tol ±%	Rating Watts	N.S. No.	Avo Part Number
R16	47k	2	0.5	MR30	26834-495
R17	15k	2	0.5	MR30	26834-483
R18	4.7k	2	0.5	MR30	26834-471
R19	1.5k	2	0.5	MR30	26834-459
R20	470	2	0.5	MR30	26835-447
R21	150	2	0.5	MR30	26834-435
R22	3.3k	2	0.5	MR30	26834-467
R23	3.3k	2	0.5	MR30	26834-467
R24	24k	1	0.25	C2114	26272-206
R25	988k	1	0.25	C2114	26276-145
R26	24k	1	0.25	C2114	26272-206
R27	10M	1	2	C2117	26274-269
R28	430k	5	2	TR8	26574-436
R29	5.6k	2	0.5	MR30	26834-473
R30	82k	2	0.5	MR30	26834-501
R31	3M	1	0.25	2114	26272-256
R32	900k	1	0.25	2114	26276-143
R33	300k	1	0.25	2114	26272-632
R34	6.2k	1	0.25	2114	26272-192
R35	80m	1		Special	A45078
R36	240m	1		Special	A45079
R37	800m	1		Special	A45080
R38	2.4	1	0.25	Special	26461-510
R39	8.02	1	0.25	Special	26463-518
R40	24.3	1	0.25	Special	26463-532
R41	82.8	1	0.25	Special	26444-232
R42	267	1	0.25	Special	26463-558
R43	1.2k	1	0.25	Special	26461-575
R44	300k	1	0.25	C2114	26272-232
R45	97.6k	1	0.25	C2114	26272-120
R46	27.6k	1	0.25	C2114	26276-108
R47	11	5	10	Welwyn AW3111	26714-326
R48	10M	5	0.5	2115	26253-269
R49	30	5	5	Welwyn AW3115	26714-136
R50	21.6k	1	0.25	C2114	26276-104
R51	21.6k	1	0.25	C2114	26276-104
R52	4.3M	5	0.25	2114	26252-260
R53	1.5M	5	0.25	2114	26252-249
R54	9M	1	0.5	2115	26277-267
R55	240	2	0.5	MR30	26834-440

RESISTORS, fixed (Contd.)

Circuit Ref	Value Ohms	Tol ±%	Rating Watts	N.S. No.	Avo Part Number
R56	240	2	0.5	MR30	26834-440
R57	240	2	0.5	MR30	26834-440
R58	240	2	0.5	MR30	26834-440
R59	240	2	0.5	MR30	26834-440
R60	240	2	0.5	MR30	26834-440
R61	240	2	0.5	MR30	26834-440
R62	240	2	0.5	MR30	26834-440
R63	240	2	0.5	MR30	26834-440
R64	4.7k	1	0.25	C2114	26272-189
R65	18k	1	0.25	C2114	26272-203
R66	9.1k	1	0.25	C2114	26272-196
R67	3.3k	2	0.5	MR30	26834-467
R68	1.3k	2	0.5	MR30	26834-458
R69	1.2k	2	0.5	MR30	26834-457
R70	33k	2	0.5	MR30	26834-491
R71	9.1k	2	0.5	5905-99-012-4750	26834-478
R72	3.3k	2	0.5	MR30	26834-467
R73	1k	2	0.5	MR30	26834-455
R74	1k	2	0.5	MR30	26834-455
R75	1.2k	2	0.5	MR30	26834-457
R76	270	1	0.25	5905-99-012-4681	26272-559
R77	3.0k	2	0.5	MR30	26834-466
R78	10k	2	0.5	MR30	26834-479
R79	6.2k	2	0.5	MR30	26834-474
R80	39k	2	0.5	MR30	26834-493
R81	15k	2	0.5	MR30	26834-483
R82	1k	2	0.5	MR30	26834-455
R83	15k	2	0.5	MR30	26834-483
R84	15k	2	0.5	MR30	26834-483
R85	33k	2	0.5	MR30	26834-491
R86	10k	2	0.5	MR30	26834-479
R87	43k	2	0.5	MR30	26834-494
R88	39k	2	0.5	MR30	26834-493
R89	15k	2	0.5	MR30	26834-483
R90	10k	2	0.5	MR30	26834-479
R91	3.3k	2	0.5	MR30	26834-467
R92	82k	2	0.5	MR30	26834-501
R93	15k	2	0.5	MR30	26834-483
R94	22k	2	0.5	MR30	26834-487
R95	220	2	0.5	MR30	26834-439

RESISTORS, fixed Contd.,

Circuit Ref	Value Ohms	Tol ±%	Rating Watts	N.S. No. or other Ref.	Avo Part Number
R96	5.6k	2	1.5	MR30	26834-473
R97	300	2	0.5	MR30	26834-442
R98	68k	2	0.5	MR30	26834-499
R99	910	2	0.5	MR30	26834-454
R100	13k	2	0.5	MR30	26834-482
R101	5M	5	2	2117	26358-182
R102	430k	5	2	TR8	26574-436
R103	100	2	0.5	MR30	26834-431

RESISTORS, Variable

Circuit Ref:	Value ohms	Tol ±%	N.S. No.	Avo Part Number
RV1	2.5k	5	5905-99-011-9498	A27231-643
RV2	500	20	5905-99-913-4258	A27111-138
RV3	500	20	5905-99-913-4258	A27111-138
RV4	500	20		C45335
RV5	5k	5	5905-99-027-2008	A27238-328
RV6	2.7k	5		A27128-354
RV7	330	5		C45076
RV8	500	20	5905-99-913-4258	A27111-138

TRANSISTORS

Circuit Ref:	Type	Manufacturer	C.V. No.	Avo Part Number
VT1	OC35	Mullard	CV7084	28526-301
VT2	NKT302	Newmarket	CV8800	28525-631
VT3	ACY21	Mullard	CV7439	28525-151
VT4	NKT302	Newmarket	CV8800	28525-631
VT5	NKT302	Newmarket	CV8800	28525-631
VT6	2S304 selected	Texas	CV7346	28532-161
VT7	BSY95A	S.T.C	CV7431	28532-201
VT8	ACY21	Mullard	CV7439	28525-151
VT9	ACY20	Mullard	CV7438	28525-152
VT10	ACY20	Mullard	CV7438	28525-152
VT11	ACY21	Mullard	CV7439	28525-151
VT12	ACY21	Mullard	CV7439	28525-151
VT13	ACY21	Mullard	CV7439	28525-151
VT14	ACY21	Mullard	CV7439	28525-151

MISCELLANEOUS

Circuit Ref:	Rating	Remarks	N.S. No.	Avo Part Number
M1	50μA.2.4kΩ + 1%		—	B45128
ILP1	24V, 2.8W Special	Osram	6210-99-995-1233	25514-659
FS1	1A	Anti-Surge	5920-99-580-0505	25411-509
FS2	1A			125413-138
T1		It Transformer	—	B45170
T2		ht Transformer	—	B45169
T3		Amplifier Input Transformer	—	B45171
PL1	3 pin Mk. 4	Mains Plug	5935-99-110-2617	A25433-006
TH1		S.T.C Type A14	5905-99-972-8938	27284-330
TH2		S.T.C Type R14	5905-99-900-5007	27284-318

SWITCHES

Circuit Ref:	Type	Facility	N.S. No.	Avo Part Number
S1	D.P.D.T.	Mains	5905-99-051-0504	A25454-251
S2	10P. 4 way	Transistor/diode Selector		C45091
S3	7P. 12 way	Function		C45090
S4	S.P.S.T.	Press for V_{DR}	5930-99-932-0974	A25472-271
S5	2P. 10 way 5P. 5 way +)	Current		C45074
S6	1P. 5 way)	h_{fe}		C45077
S7	S.P.D.T.	Slide	Arcolectric	A25472-645
S8	1P. 10 way	Set I_C		C45335
S9	1P. 10 way	Set I_{DF}		C45076

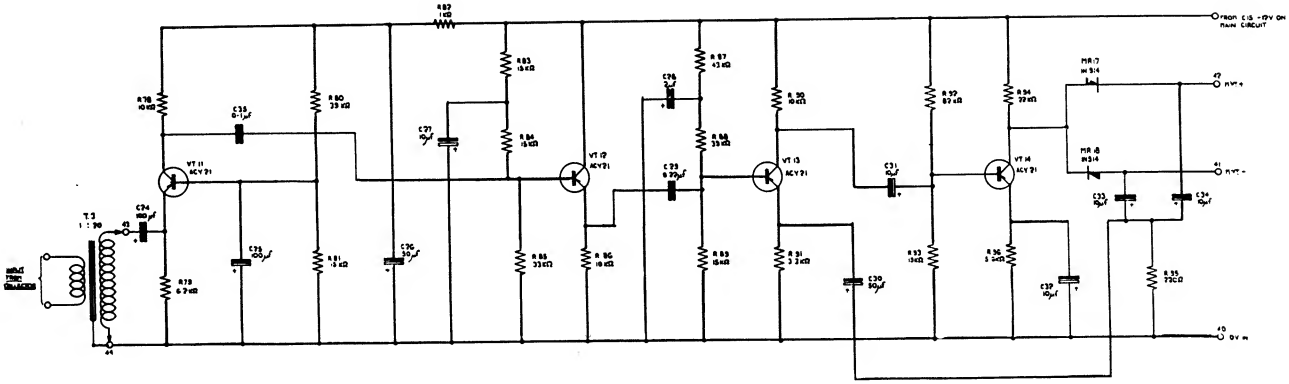


Fig. 5. AMPLIFIER CIRCUIT DIAGRAM.

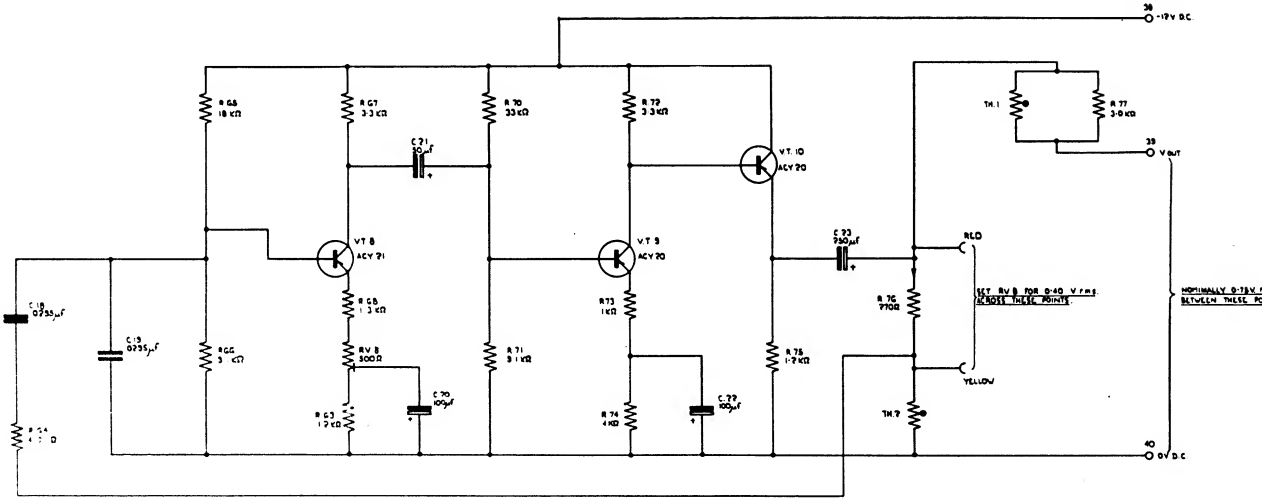
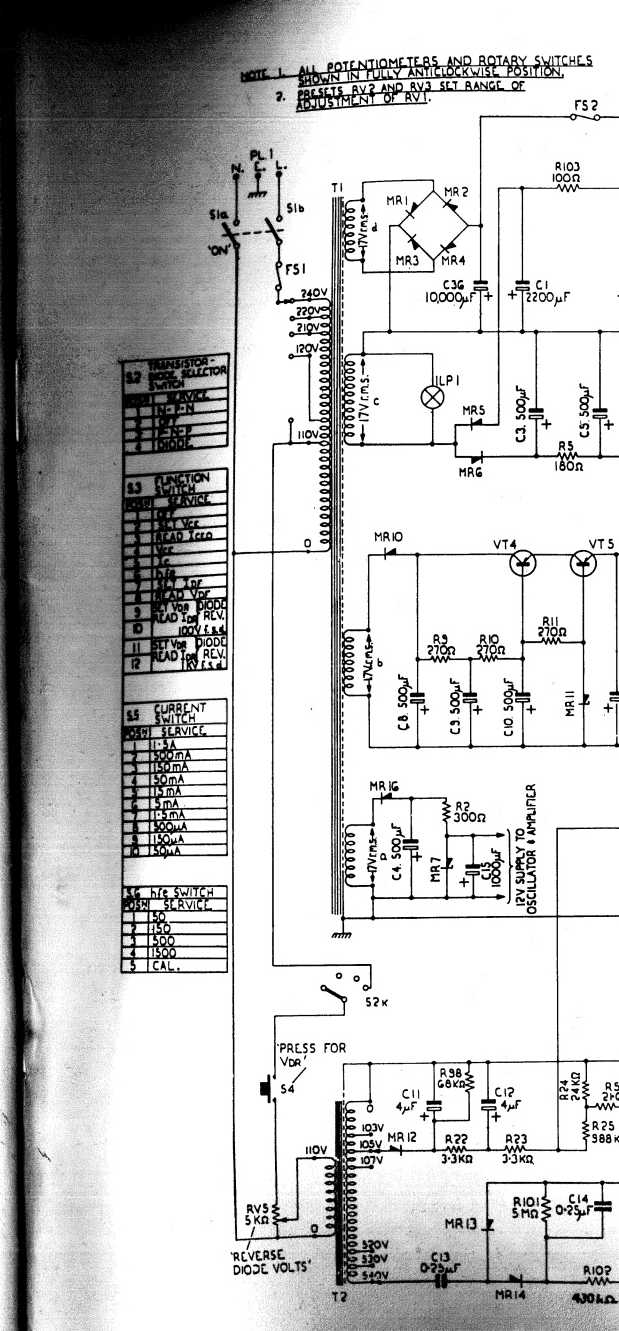


Fig. 6. OSCILLATOR CIRCUIT DIAGRAM.


NOTE 1. ALL POTENTIOMETERS AND ROTARY SWITCHES SHOWN IN FULLY ANTICLOCKWISE POSITION.
2. PRESETS RV2 AND RV3 SET RANGE OF ADJUSTMENT OF RV1.
S2 TRANSISTOR - DIODE SELECTOR SWITCH
POSN SERVICE
1 NPN
2 PNP
3 ZENER
4 DIODE
S3 FUNCTION SWITCH
POSN SERVICE
1 OFF
2 SET Vce
3 READ Iceo
4 Vce
5 Ic
6 hfe
7 SET Vbe
8 READ Vbe
9 SET Vbr READ Ibr DIODE REV. 100V f.s.d.
10
11 SET Vbr READ Ibr DIODE REV. 10V f.s.d.
12
S5 CURRENT SWITCH
POSN SERVICE
1 1·5A
2 300mA
3 150mA
4 50mA
5 15mA
6 5mA
7 1·5mA
8 500µA
9 150µA
10 50µA
S6 hfe SWITCH
POSN SERVICE
1 50
2 150
3 500
4 1500
5 CAL.
PL1
N
E
L
S1a
S1b
'ON'
FS1
240V
220V
210V
120V
110V
0
T1
17Vrms a
17Vrms b
17V r.m.s. c
MR1
MR2
MR3
MR4
C3G 10,000µF
C1 2200µF
R103 100Ω
ILP1
MR5
MR6
C3 500µF
C5 500µF
R5 180Ω
MR10
VT4
VT5
R9 270Ω
R10 370Ω
R11 270Ω
C8 500µF
C9 500µF
C10 500µF
MR11
MR16
R2 300Ω
C4 500µF
MR7
C6 1000µF
12V SUPPLY TO OSCILLATOR & AMPLIFIER
S2K
'PRESS FOR Vbr'
S4
C11 4µF
R98 68KΩ
C12 4µF
R24 24KΩ
R25 988K
103V
105V
107V
MR12
R22 3·3KΩ
R23 3·3KΩ
110V
RV5 5KΩ
'REVERSE DIODE VOLTS'
R101 5MΩ
C14 0·25µF
MR13
320V
330V
340V
C13 0·25µF
MR14
T2
R102
430KΩ

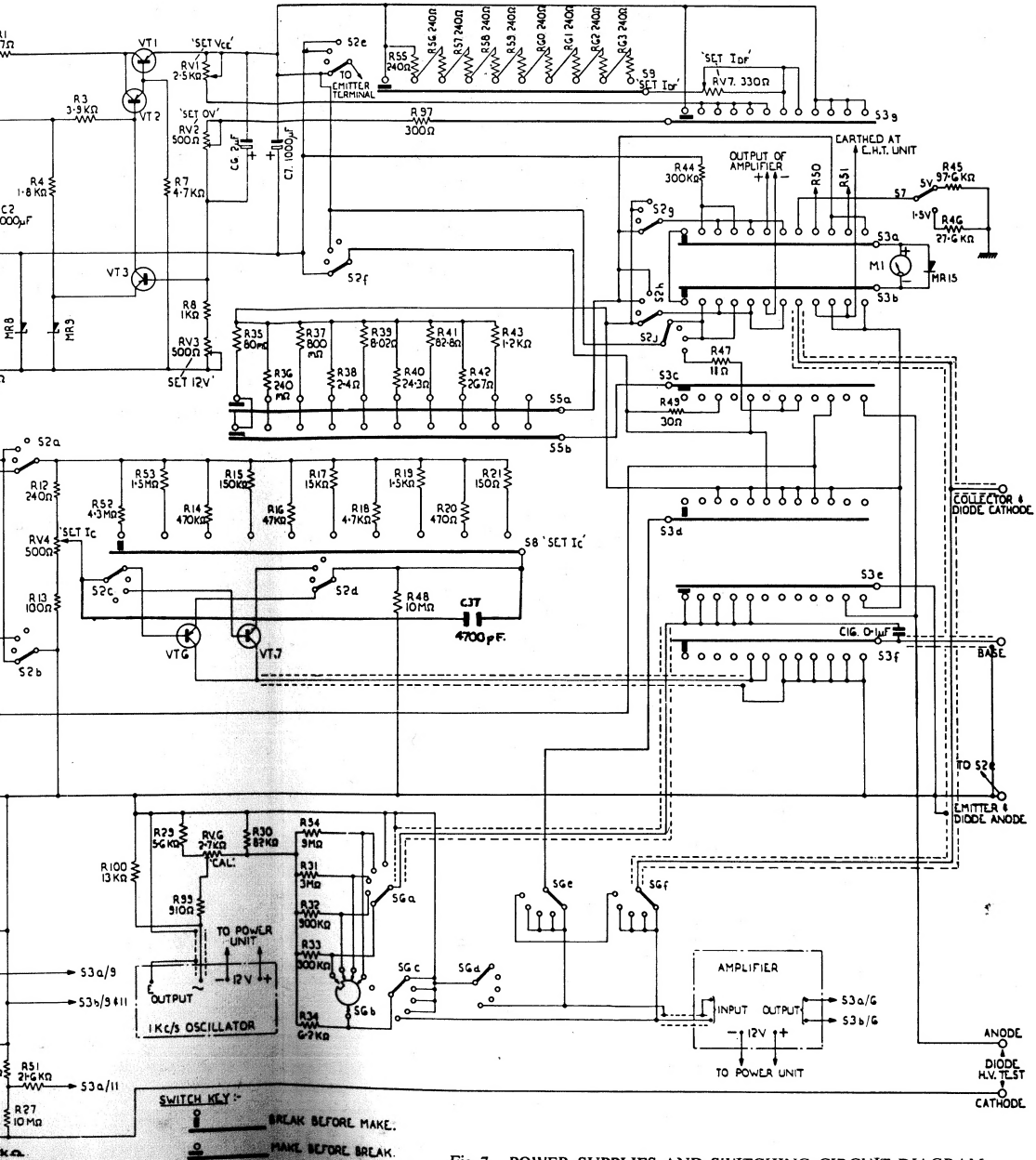
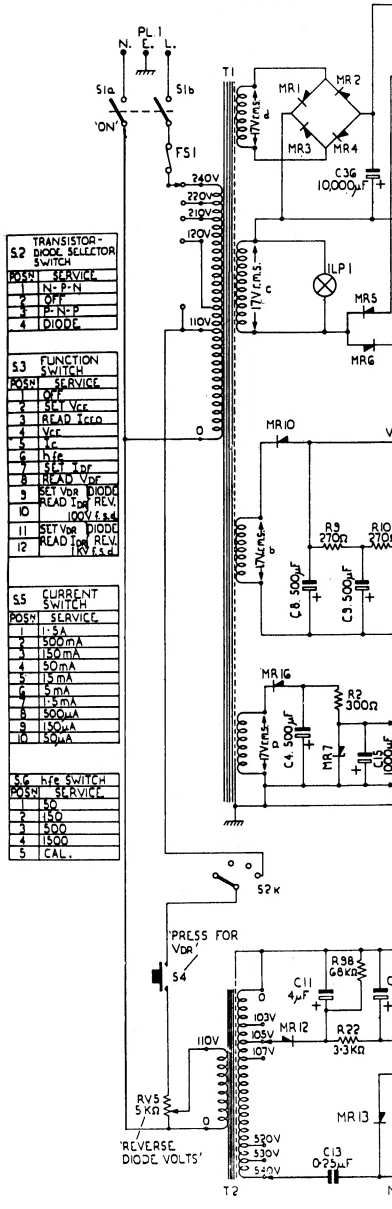


Fig. 7. POWER SUPPLIES AND SWITCHING CIRCUIT DIAGRAM

NOTE 1. ALL POTENTIOMETERS AND ROT
SHOWN IN FULLY ANTICLOCKWISE
2. PRESETS RV2 AND RV3 SET RANGE
ADJUSTMENT OF RV1.



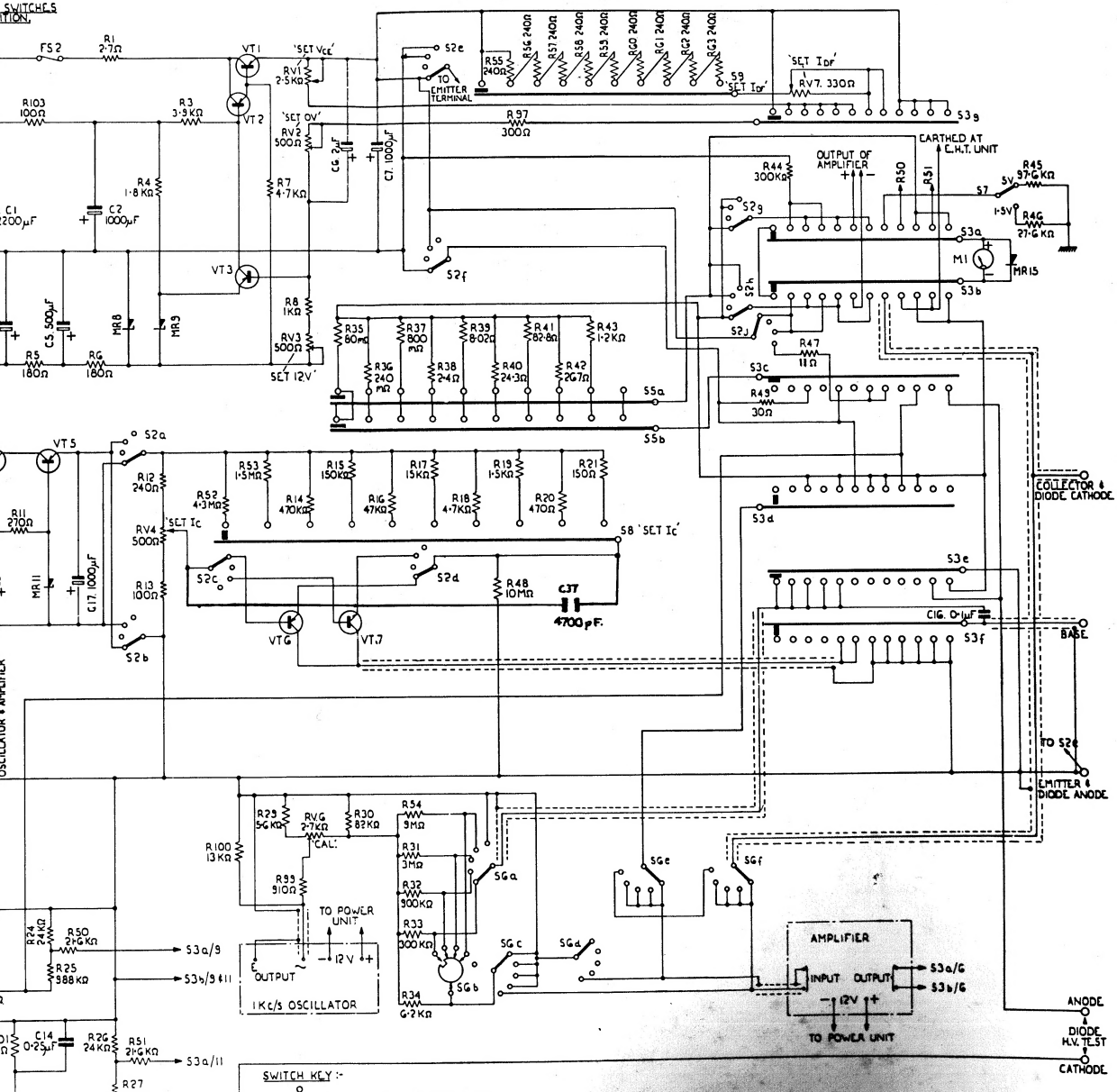


Fig. 7. POWER SUPPLIES AND SWITCHING CIRCUIT DIAGRAM